Ulysses-UVCS Coordinated Observations

S. T. Suess
NASA Marshall Space Flight Center, Huntsville, AL, USA

G. Poletto and G. Corti
Osservatorio Astrofisico di Arcetri, Firenze, Italy

G. Simnett
University of Birmingham, United Kingdom

G. Noci and M. Romoli
Universitá di Firenze, Italy

J. Kohl
Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA

B. Goldstein
Jet Propulsion Laboratory, Pasadena, CA, USA

Abstract. We present results from SOHO/UVCS measurements of the density and flow speed of plasma at the Sun and again of the same plasma by Ulysses/SWOOPS in the solar wind. UVCS made measuremnts at 3.5 and 4.5 solar radii and Ulysses was at 5.1 AU. Data were taken for nearly 2 weeks in May-June 1997 at 9-10 degrees north of the equator in the streamer belt on the east limb. Density and flow speed were compared to see if near Sun characteristics are preserved in the interplanetary medium. By chance, Ulysses was at the very northern edge of the streamer belt. Nevertheless, no evidence was found of fast wind or mixing of slow wind with fast wind coming from the northern polar coronal hole. The morphology of the streamer belt was similar at the beginning and end of the observing period, but was markedly different during the middle of the period. A corresponding change in density (but not flow speed) was noted at Ulysses.

Key words: SOHO, Ulysses, Streamers

1. The Observations

On 26 May 1997 (DoY 146) the Ulysses - Sun - SOHO angle was 90^o, presenting an opportunity to observe a solar wind limb source with SOHO and later observe the same solar wind *in situ* at Ulysses. This opportunity occurs only about twice a year. Ulysses was at 5.1 AU, 10^o north of the heliographic equator and off the east limb. It was near sunspot minimum so the streamer belt was confined to low latitudes.

LASCO/C2 images and Ulysses data are shown in Fig. 1. At 400 km/s, it takes solar wind three weeks to reach 5 AU. Therefore, we analyzed data for two weeks centered on 16 June (DoY 167). These were extrapolated backwards in time to the solar source assuming constant speed. Since the uncertainty in such extrapolations is $\sim \pm 10$ degrees

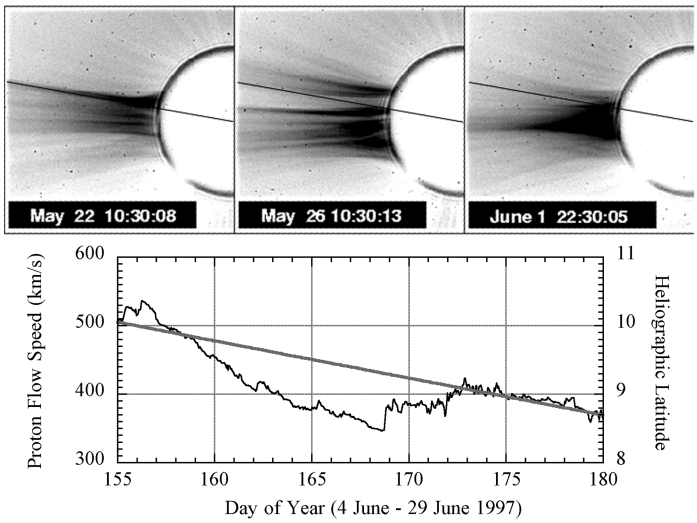

Figure 1. Top: Negative, edge enhanced LASCO/C2 images on 22 May, 26 May, and 1 June 1997. The black line shows the direction to Ulysses. Bottom: SWOOPS solar wind speed and Ulysses latitude over the interval when wind from 22 May - 1 June 1997 would have reached Ulysses.

and the Ulysses-SOHO angle changes by $\sim 1^o$/day, the plasma from this entire period can be approximated as having originated at the limb. Extrapolation results are in Fig. 2, where the small forward shock on DoY 168 has resulted in the gap in the extrapolated flow speed.

The flow speed in Fig. 2 is constant from DoY 141 to 154 (22 May - 1 June). This is unusual for slow wind (McComas et al., 1998) and reflects the quiet conditions in the corona. Comparing this with the LASCO images in Fig. 1, it is seen that the latitude of Ulysses was always inside the streamer (barely inside on 22 May). However, the appearance of the corona underwent large changes. First, the streamer belt was narrow, well defined, and had a sharp northern boundary. Next, the streamer belt fanned out to a wide angle. Finally, the streamer belt returned to being thin with a sharp northern boundary. UVCS detected similar streamer morphology at this time.

The UVCS O^{5+} 1032 to 1037Å line ratio, R, gives an estimate for the plasma outflow speed without the modeling necessary to compute quantitive speeds (Kohl et al., 1997). These ratios are shown in Fig. 2. At 3.5 R_S R=2.6-2.7 (except on 23 May) while at 4.5 R_S $1.8 < R < 2.0$. $2 < R < 4$ implies $v < 100$ km/s while $R \leq 2$ implies $v > 100$ km/s from Doppler dimming. Therefore, Fig. 2 implies $v < 100$ km/s at 3.5 R_S and $v > 100$ km/s at 4.5 R_S. The data (except on 23 May) are also consistent with no time variation, as observed at Ulysses. However, we

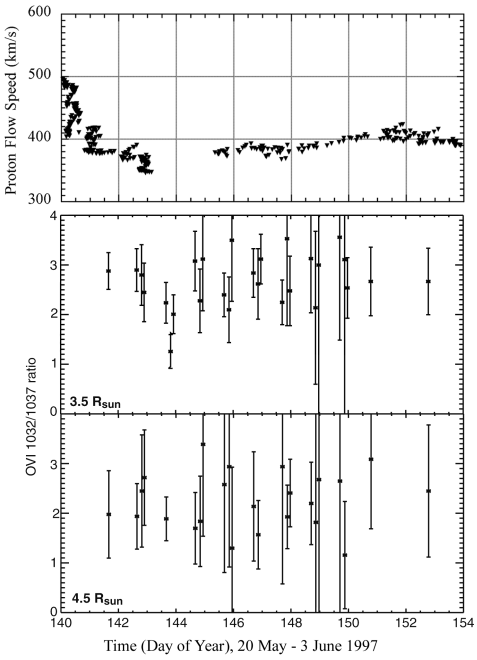

Figure 2. Top: Solar wind flow speed extrapolated to the Sun using the constant velocity approximation. Bottom: UVCS OVI 1032/1037 Å ratio at 3.5 and 4.5 R_S and $9 - 10^o$ latitude over the interval Ulysses was off the Solar limb.

note that the 1σ error bars shown in Fig. 2, especially those on DoY 149/150, imply considerable uncertainty in these results.

SWOOPS density extrapolated to the Sun is shown in Fig. 3. This is compared with UVCS Ly-α intensity, which is a density proxy (Ly-α intensity is not directly equivalent to density since it is convolved with flow speed and kinetic temperature). The uncertainty in $I_{Ly-\alpha}$ is $< 5\%$ and therefore not displayed in this figure. $I_{Ly-\alpha}$ changes over the target interval by less than a factor of two, but there are definite "sub-intervals" that seem distinct from each other. Sub-intervals I1, I2, and I3 correspond in time with the LASCO/C2 visual changes in Fig. 1. The sub-intervals also seem to have a counterpart in the density at Ulysses in Fig. 3.

2. Summary & Conclusions

• If is assumed the bright streamer boundary is the fast/slow wind boundary, then the solar wind moves little in latitude between a few R_S and 5 AU. Also, there is no obvious mixing due to shear instabilities.

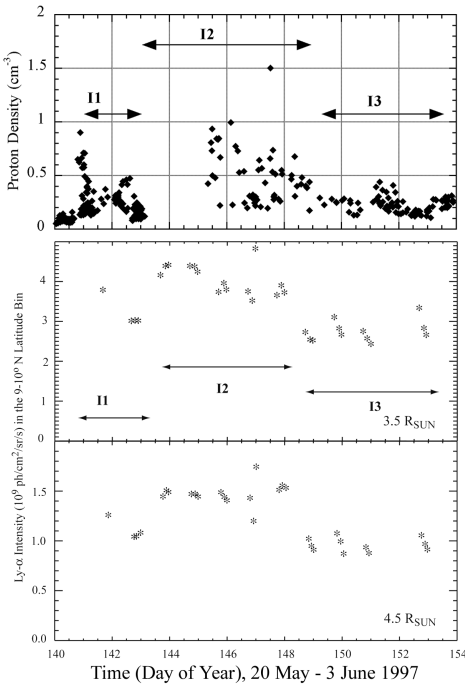

Figure 3. Top: SWOOPS density extrapolated to the Sun. Bottom: UVCS Ly-α intensity at several times over the interval Ulysses was off the Solar limb.

• The slow wind has the same speed independent of the visual streamer appearance, both near the Sun and at 5 AU.
• The broadening of the streamer corresponds both to enhanced $I_{Ly-\alpha}$ and to enhanced solar wind density.

Acknowledgements

This research has been supported by the Ulysses/SWOOPS and SOHO/UVCS projects.

References

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McComas, D. J., and 11 others: 1998, *Geophys. Res. Lett.*, **25**, 1-4.

Address for correspondence: S. T. Suess, NASA Marshall Space Flight Center, Mail Stop ES82, Huntsville, AL 35812, USA